The recovery faunas and Lazarus taxa of the Pliocene Nicosia Formation, central Mesaoria Plain, Cyprus

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INTRODUCTION

The island of Cyprus, located in the eastern Mediterranean, is characterized by the Troodos Massif, a well exposed ophiolite complex dating from the Late Cretaceous, approximately 85 to 92 million years ago (Mukasa and Ludden, 1987; Moores and Vine, 1971). The obduction of the Troodos ophiolite has resulted in the subsequent uplift and exposure of its sedimentary cover, allowing the study of these sediments and the fossils preserved within them.

Of particular interest to this study is the Pliocene Nicosia Formation, which is exposed north of the Troodos Massif on the flanks of mesas on the Mesaoria Plain. Up to 900 meters thick and composed mostly of marine silts with some conglomerates and sandstones, the Nicosia Formation unconformably overlies the evaporitic gypsums of the Miocene Kalavasos Formation, which were deposited during the Messinian salinity crisis (Table 1). The silts of the Nicosia Formation mark the return of open marine conditions to the Cyprus area following the Messinian salinity crisis (McCallum and Robertson, 1990).

Many fossils, mostly bivalves, gastropods, and foraminiferans, are well preserved in the silts of the Nicosia Formation. These fossils record the repopulation of the Mesaoria basin following the Messinian salinity crisis, providing an excellent opportunity to study the recovery faunas.

Eight distinct paleocommunities comprised of 75 species have been identified in the Nicosia Formation south and southwest of the village of Meniko on the central Mesaoria Plain. Each paleocommunity has a unique guild structure and dominant species. Most are dominated by epifaunal filter feeders and all contain the common oyster *Ostrea*.

The hypotheses being tested in this study are that there were no refuges for marine invertebrates in the Mediterranean basin during the Messinian salinity crisis, and that the repopulation of the Cyprus invertebrate marine faunas came from the Atlantic and the Indo-Pacific.

According to Wright and Cita (1973), the issue of whether or not there were refuges for marine invertebrates in the Mediterranean basin during the Messinian salinity crisis is open to much debate. The subject needs clarification through further study (Wright and Cita, 1973).

It should be noted that the only reason the pre- and post-crisis faunas of Cyprus can be compared to one another is that they are preserved in formations with similar, if not the same, depositional environments. Both the Miocene Pakhna Formation and the Pliocene Nicosia Formation are primarily composed of silts deposited in low energy shallow marine environments, and their exposures are nearly indistinguishable.

Additionally, the Pakhna Formation is overlain in places by the evaporite gypsums of the Kalavasos Formation, while the Kalavasos Formation is overlain by the Nicosia Formation (Table 1). This stratigraphic relationship places these two formations, the Pakhna and Nicosia Formation, as the ideal recorders of the pre- and post-crisis faunas on Cyprus.

METHODS

Fossiliferous localities were located through reconnaissance and, in most cases, fossils were collected in randomly placed one square meter areas. Every fossil visible at the surface of each square meter was collected to reduce collection bias. Twelve or thirteen of these square meters were collected at each site. Some sites were small enough that an attempt was made to collect every fossil visible at the surface of the entire site.

Once the fossils were identified and the paleoecology of each paleocommunity was reconstructed (which has not been done before in the Cyprus Tertiary), an attempt was made to determine, through the previous paleontological literature of Cyprus, how many species of the Miocene, or pre-crisis, faunas were also present in the Pliocene, or post-crisis, faunas. These species are called Lazarus taxa because they appear to go extinct during an extinction event, only to reappear in the fossil record (Jablonski, 1986). The data from this study was combined with that of

Cowper Reed (1933, 1935, 1935, 1940), who worked on both the Miocene and Pliocene paleontology of Cyprus, in order to calculate what percentage of the Pliocene faunas of Cyprus are Lazarus taxa.

RESULTS and DISCUSSION

Of the 412 different species found in the marine silts of the Pliocene Nicosia Formation of Cyprus by Cowper Reed (1935, 1940) and this study, only 21 were also found in the marine silts of the Miocene Pakhna Formation by Cowper Reed (1933, 1935). These numbers mean that only 5.1% of the species in the post-crisis faunas are Lazarus taxa.

The 21 species which are Lazarus taxa are dominated by 19 heterodont, arcid, and pectenid bivalves (Table 2). The preponderance of these bivalves may be due to the fact that they have fewer species-level diagnostic criteria than more morphologically complex organisms, allowing for convergent species to be taxonomically confused. If this is the case, then many of the Lazarus taxa of the Pliocene Nicosia Formation of Cyprus may actually be Elvis taxa, species that appear to return following an extinction event, but actually do not (Erwin and Droser, 1993). However, the wide geographical distribution and generalist adaptability of the arcid bivalves make them likely to be true Lazarus taxa (Thomas, 1978).

The origins of numerous species in the post-crisis faunas of the Mediterranean Sea have been identified with some accuracy. Several species of venerine bivalves have been traced back to Atlantic origins, and a few gastropod and bivalve species may have Indo-Pacific origins (Jones, 1984; Grecchi, 1978). It therefore seems quite possible that the post-crisis faunas of Cyprus have both Atlantic and Indo-Pacific origins.

The next and final stage in this study is to examine the paleontological literature of these apparent Lazarus taxa in order to determine, as accurately as possible, their origins. If it is found that most of the Lazarus taxa are endemic to the Mediterranean Sea, then there would be no support for either of the hypotheses of this study.

CONCLUSIONS

At this stage of the study, it appears that there is good support for the hypothesis that there were no refuges for marine invertebrates in the Mediterranean basin during the Messinian salinity crisis. Only 5.1% of the post-crisis species of Cyprus are Lazarus taxa. Such a low percentage seems to indicate that the Messinian salinity crisis had an almost sterilizing effect on the marine invertebrate life in the Mediterranean Sea.

It still remains to be determined whether or not the hypothesis that the repopulation of the Cyprus faunas came from the Atlantic and the Indo-Pacific will be supported.

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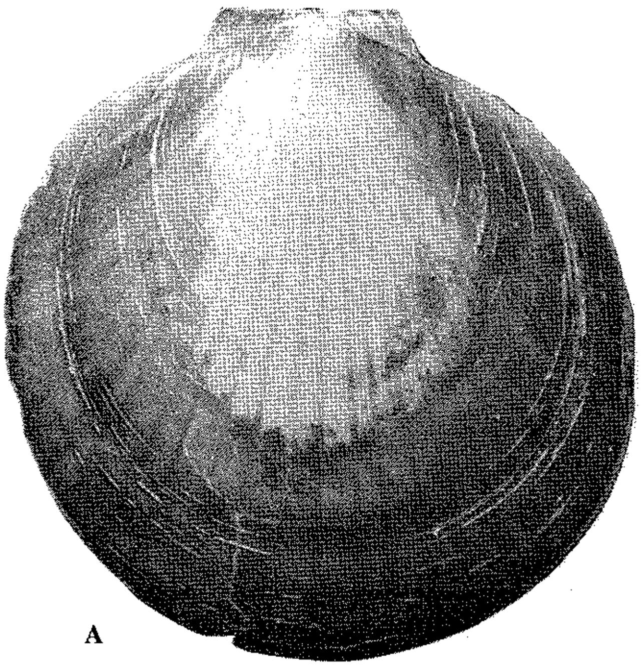
AGE	FORMATION	MAX. THICKNESS	FACIES
Lower-Upper Pliocene	Nicosia Formation	900 meters	Featureless calcareous silts with marine fossils, very fine sandstones, conglomerates.
Upper Miocene (Messinian)	Kalavasos Formation	150 meters	Evaporite gypsums.
Upper Miocene	Koronia Formation	150 meters	Limestones, patch reefs.
Middle-Upper Miocene	Pakhna Formation	700 meters	Fossiliferous calcareous marine silts, sandstones, conglomerates.

Table 1. Geological summary of the Miocene and Pliocene of the Mesaoria basin, Cyprus (after McCallum and Robertson, 1990, and Greensmith, 1994).

BIVALVES	GASTROPODS
Amusium cristatum	*Diodora italica*
Anadara diluvii	*Turritella subangulata*
Arca noae	
Barbatia barbata	
Cardium hians	
Cardium multicostatum	
Cardium papillosum	
Chama gryphina	
Chama gryphoides	
Corbula gibba	
Limopsis (Pectunculus) anomala	
Liostrea cochlear	
Lucina (Dentilucina) meneghini	
Lucina (Myrtea) spinifera	
Meretrix (Callista) chione	
Pectunculus insubricus	
Striarca lactea	
Venus (Timoclea) ovata	
Yoldia longa	

Table 2. Lazarus taxa of the Pliocene Nicosia Formation, Cyprus.



A

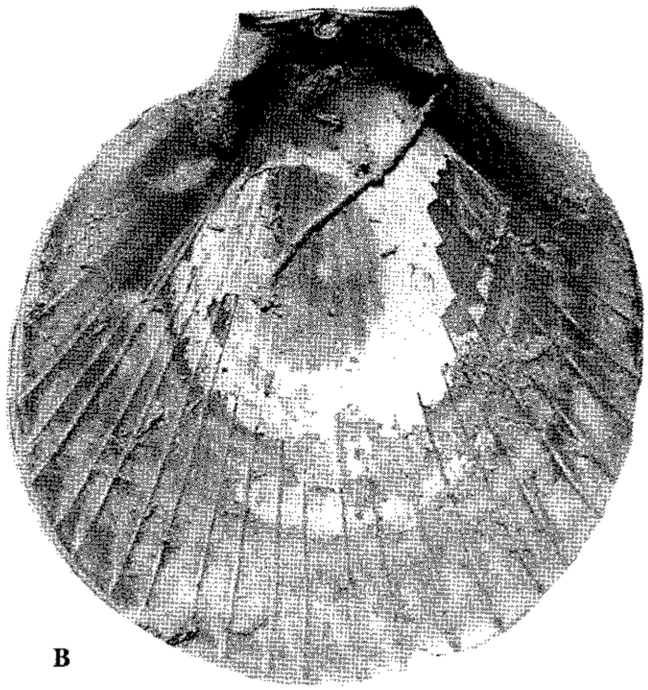


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Figure 1. A. Left valve exterior of *Amusium cristatum* (x 1.2);
B. Left valve interior of *Amusium cristatum* (x 1.2).